GENERAL PURPOSE
THERMAL MASS FLOWMETER
MODEL 4140/4143

OPERATION AND SERVICE MANUAL

P/N 1980383, REVISION F
APRIL 2015

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WARNING

TSI flowmeters employ a heated platinum sensor. They should not be used with flammable or explosive gasses or mixtures.

Caution

TSI flowmeters are not medical devices under FDA 510k and in no situation should they be utilized for human respiration measurements.

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Chapter 1

Unpacking and Parts Identification

Carefully unpack the instrument and accessories from the shipping container. Check the individual parts against the list of components in Table 1. If any parts are missing or damaged, notify TSI immediately.

Table 1. List of Components

Qty	Item Description	Part/ Model
1	Mass Flowmeter, 0.25 inch inlet/outlet (Air, Oxygen, Nitrogen) Mass Flowmeter, 0.25 inch inlet/outlet (Air, Oxygen, Nitrogen, Nitrous Oxide)* Mass Flowmeter, 0.375 inch inlet/outlet (Air, Oxygen, Nitrogen) Mass Flowmeter, 0.375 inch inlet/outlet (Air, Oxygen, Nitrogen, Nitrous Oxide)*	4140 41403 4143 41433
1	Filter Model 4140: 60 mm ULPA filter with 0.25 inch barbed fittings Model 4143: 63 mm HEPA filter with 0.375 inch barbed fittings	 1602317 1602342
1	AC Adapter 100 to 240 V, N. America NEMA 5-15 plug, grounded 100 to 240 V, Europlug, CEE 7/16, grounded 100 to 240 V, Great Britain, grounded, fused 100 to 240 V, Australia/NZ	 8918-NA 8918-EC 8918-GB 8918-AT
1	Operation and Service Manual for Model 4140/4143	1980383
1	RS232 Serial Command Set Manual, 4000/4100	1980340

*Other than the specifications in Appendix A, all references to 4140 and 4143 in this manual apply to the 41403 and 41433, respectively.

Table 2. Optional Accessories

Item Description	Part/Mode
Computer Cable, mini-DIN to 9-pin RS-232	1303583
Analog Cable, mini-DIN to cable with tinned wires	1303584
Carrying Case for Model 4140/4143	1319201

Parts Identification

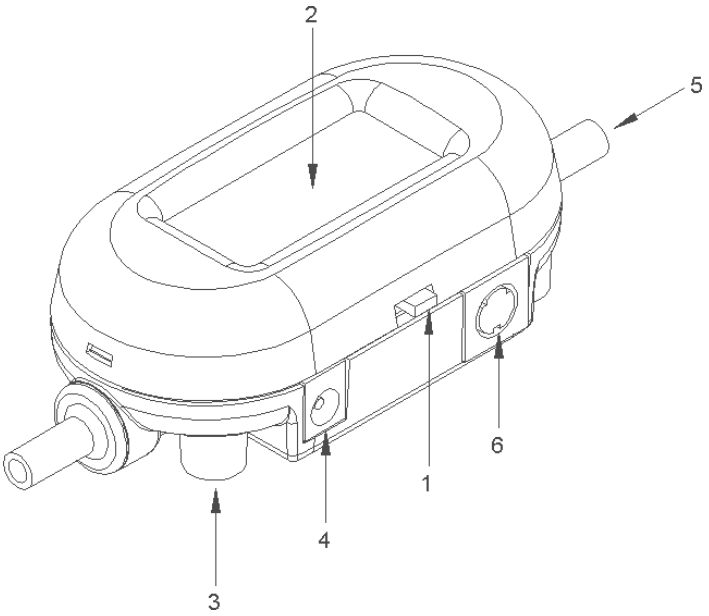


Figure 1-1 Model 4140/4143 Mass Flowmeter

1. On/Off Switch
2. Display
3. Mounting Inserts (2)
4. DC Power Input
5. Flow Inlet
6. Computer Serial Interface, Analog Output, and Optional Power Input Connection

Chapter 2

Setting-Up

Supplying Power
The flowmeter can be powered in one of two ways: through the power jack using the supplied AC adapter or through the mini-DIN connector. The DC power input connector is shown below along with the power requirements.

Power Supply: 7.5 VDC ± 1.5 V, 300 mA maximum

When supplying power through the optional TSI interface cable, line up the arrow on the connector with the bottom side of the flowmeter. Flowmeter connector pin-out designations are shown below.

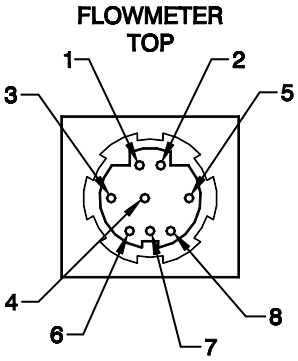


Table 3. Connector Pin-out and Color Code for TSI Cable PN 1303584

Pin	Function	Cable Color Code
1	Power Input (+)	Black
2	Power Ground (-)	Green
3	Analog Output (+)	Red
4	Analog Ground (-)	Brown
5	(no connection)	Blue
6	RS232 Receive (in)	White
7	RS232 Transmit (out)	Yellow
8	Logic Ground	Gray

Connecting Filter and Flow Tubes
The Model 4140/4143 has a thermal sensor exposed to the gas flow that must be protected from foreign matter and particles. TSI supplies a filter that should be connected to the inlet of the flowmeter, however, any filter will work as long as it has a minimum efficiency of 99.9%.

CAUTION

Always use a filter on the inlet of the flowmeter. Failure to filter the gas flow may change the calibration and/or permanently damage the sensor.

Note: Flow direction is identified by the large arrow printed on the bottom side of the flowmeter.

After attaching the filter connect the flow tube to the inlet of the filter. Connecting a tube to the outlet of the flowmeter will create back pressure. See Appendix A for flowmeter accuracy specifications when operating at various pressures. In general, minimize back pressure on the flowmeter to maintain higher accuracy.

RS232 Configuration and Operation
Many flowmeter operating parameters can be easily configured through the RS232 serial port. Likewise, the flow rate, temperature, pressure, and volume can be read through the serial port. Refer to the ***Series 4000/4100 RS232 Serial Command Set*** manual for a detailed description of the commands and command syntax.

RS232 Settings:
Baud Rate .....38.4 k
Data Bits.....8
Parity.....None
Stop Bits.....1
Flow Control.....None

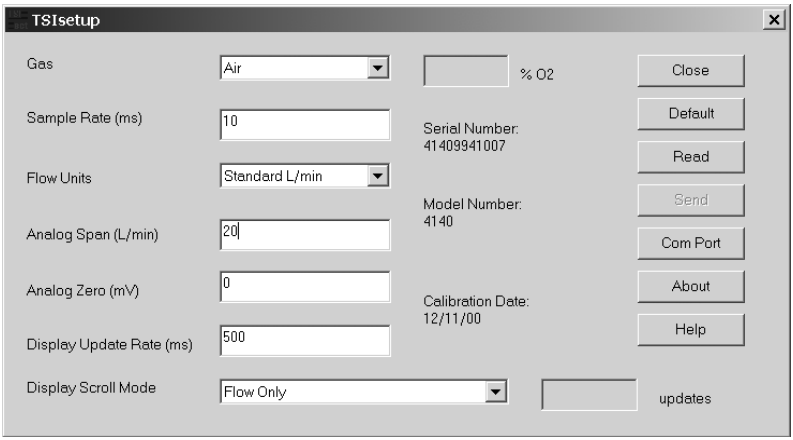
Table 4. Changeable Operating Parameters

Function	Command
Select Gas Calibration air, O_2, N_2, or N_2O(if available)	SGn
Select Standard or Volumetric Flow Measurement	SUn
LCD Display Update Rate (controls averaging)	SURnnnn
Select Measurement Display Scroll Mode	SDMFTPn
Select Measurement Displayed on LCD Display	SDMm
Select Measurement Units on LCD Display	SDUn
Select Data Update Rate for Analog Output	SSRnnnn
Set Analog Output Full-Scale Flow Rate Value	SASnnn
Set Analog Output Zero Value	SAZnnn

Configuration Software
TSI has several software utilities to help you communicate with your flowmeter to change parameters and to obtain flow data. You can download the latest versions of these at no charge from our web site:

http://flowmeters.tsi.com

1. If you only want to change one or more of the operating parameters shown in Table 4 (above), the easiest way is to use the software utility called ***"TSI setup."*** This uses convenient drop-down menus to help change these parameters. After you have made your changes, be sure to click on "Send" to store the changes in the flowmeter's memory.



2. If you want to communicate directly with the flowmeter using the basic RS232 commands shown in the ***Serial Command Set Manual***, you can use a terminal program. HyperTerminal is a common terminal program that is included with most versions of the Microsoft operating system. Setting up HyperTerminal to communicate with your flowmeter can sometimes be confusing. You can download a document from our web site that helps you configure HyperTerminal. Download the document called ***"Using HyperTerminal to communicate with TSI Flowmeters."***

3. If you plan to develop a more sophisticated program for data collection and control using LabVIEW, you can download a demonstration program called ***"Real-time Demo Program"*** and the source code ***"Source Code for Real-time Demo Program."*** This program is intended to be a basic demonstration program and not a practical laboratory tool. It does, however, have a convenient implementation of the VOLUME measurement function that can be useful for basic tests.

Chapter 3

Operation

CAUTION

TSI flowmeters are not medical devices under FDA 510k and in no situation should they be utilized for human respiration measurements.

Overview
The Model 4140/4143 Flowmeter measures mass flow rate, temperature and absolute pressure of the gas inside the flow tube. All measurements made by the Models 4140/4143 are NIST traceable.

ON/OFF Switch
Slide the switch to the ON position. The power switch is marked in the international symbols '|' for *on* and 'O' for *off*.

Warm-up Time
The flowmeter will provide readings immediately upon power-up. Recommended warm-up time of the flowmeter is 5 minutes.

Flow Rate Measurement
Flow rate data can be obtained from the Model 4140/4143 through the LCD display, RS232 serial port, or the linearized analog output. The analog output is a 0 to 10 volt DC linear signal representing 0 to 20 Std L/min. The analog output scaling is user selectable. Refer to the ***Series 4000/4100 RS232 Serial Command Set*** manual for instructions on how to obtain flow data through the serial port.

Gas calibrations (air, 100% O_2, 100% N_2 or 100% N_2O) can be selected through the RS232 serial port. Refer to the ***Series 4000/4100 RS232 Serial Command Set*** manual. The LCD display will indicate the calibration being utilized: air, O_2, N_2, or N_2O.

Flow can be displayed in units of standard liters per minute (Std L/min*) or in volumetric units of liters per minute (L/min). Refer to Appendix B for a description of the two measurements. Selecting between the two measurements is accomplished through the serial port. Refer to the

*TSI instruments defines standard conditions as 21.1°C (70° F) and 101.3 kPa (14.7 psia, 1 bar).

Series 4000/4100 RS232 Serial Command Set manual for instructions on how to select between flow units.

The Model 4140/4143 has an independent temperature sensor in the flow tube to measure the gas temperature. The temperature sensor is used for temperature compensation of flow rate and for converting flow from standard to volumetric units. Temperature can also be displayed on the LCD and is available through the RS232 serial port in the units of degrees Celsius (°C).

Note: At low flow rates, the temperature inside of the flow tube will increase because of the heat generated by the thermal flow sensor. This effect is normal and the temperature of the incoming gas will be measured once flow resumes.

Pressure Measurement
The Models 4140/4143 measure absolute pressure near the outlet of the flowmeter in the SI units of kilo-Pascals (kPa). Pressure measurements are required when converting from standard to volumetric flow. Absolute pressure can be displayed on the LCD and is available through the RS232 serial port.

Select Measurement Displayed
By using RS232 commands the LCD display can be set up to continuously display either flow rate, temperature, or pressure. See the **SDMm** command in the ***Series 4000/4100 Serial Command Set*** manual.

Display "Scroll" Mode
By using RS232 commands the LCD display can be set up to continuously scroll between flow rate, temperature, and pressure. The scroll rate is adjustable and the user can specify the parameters to be displayed. See the **SDMFTPn** command in the ***Series 4000/4100 Serial Command Set*** manual.

Volume Measurement
These flowmeters measure total volume by integrating flow over time. This is a calculated measurement performed by the flowmeter and is only available using the RS232 serial port. Volume is not displayed on the LCD display. Refer to the ***Series 4000/4100 RS232 Serial Command Set*** manual for instructions on using the volume function.

Chapter 4

Maintenance

Flow Sensor
Periodically inspect the flow sensor by looking into the outlet of the flowmeter. Remove dust, particles and fibers from the sensor with clean, dry compressed air. The flow sensor will break if touched. ***Never run liquids through the flowmeter and never touch the sensor with a brush.*** Dust or other deposits on the flow sensor will degrade the 4140/4143 flowmeter's flow accuracy.

	CAUTION
	The flowmeter must be switched off for cleaning. Only use clean, dry, compressed air when attempting to remove contamination from the sensor.

Re-certification
To maintain a high degree of confidence in the measurements made by the Model 4140/4143, TSI recommends that the instrument be returned to TSI every 12 months for re-certification. The flowmeter will be recalibrated and returned with a certificate of calibration to US National Institute of Standards Technology (NIST) traceable standards. This "annual checkup" assures you of consistently accurate readings; it is especially important in applications where strict calibration records must be maintained.

Cases
If the instrument case or storage case needs cleaning, wipe it off with a soft cloth dipped in isopropyl alcohol or mild detergent. ***Never*** submerge the flowmeter or allow liquids to enter the flow tube.

Storage
When storing the flowmeter, always cover the ends of flow tubes with the caps provided to prevent dust or other foreign matter from entering the tube.

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Chapter 5

Troubleshooting

Table 4 lists the symptoms, possible causes, and recommended solutions for common problems encountered with Series 4100 flowmeters. If the symptom is not listed, or if none of the solutions solves the problem, please contact TSI Customer Support at 1-800-874-2811 or 651-490-2811.

Table 4. Troubleshooting

Symptom	Possible Causes	Corrective Action
No display.	Unit not switched on.	Switch on the unit.
	No power to instrument.	Plug in AC adapter or check power source on mini-DIN connector.
Temperature reads high at low or zero flows.	Temperature sensor is being heated from the flow sensor.	The temperature value will track the actual gas temperature once the flow rate through the flowmeter exceeds 1 Std L/min.
Flow readings fluctuate greatly.	The flow is fluctuating.	Improve inlet conditions or increase display averaging time.
Display shows flows over-range with no flow passing through flow tube.	The sensor may be damaged or broken.	Return flowmeter to TSI for service.

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Appendix A

Specifications*

Flow Measurement	
Measurement Range.....	0.01 to 20 Std L/min.
Accuracy	
Air and 100% O_2.....	2% of reading or .005 Std L/min, whichever is greater,
100% N_2	3% of reading or .010 Std L/min, whichever is greater,
100% N_2O ..... *(41403 and 41433 only)*	3% of reading or .010 Std L/min, whichever is greater, Accuracy stated at standard conditions (21.1°C and 101.3 kPa) See notes **1** through **6** below.
Resolution (Display).....	0.001 Std L/min between 0.01 and 9 Std L/min 0.01 Std L/min between 9 and 20 Std L/min
Response	Less than 4 msec, 63% of final value at full scale flow
Temperature Measurement	
Measurement Range.....	0 to 50°C
Accuracy	±1°C, at flows greater than 1 L/min. See note **2** below.
Resolution (Display).....	0.1°C
Response	Less than 75 msec, 63% of final value for 20°C step change in temperature at full scale flow
Static Pressure Measurement (Measured inside flow tube near the exit)	
Measurement Range.....	50 to 199 kPa Absolute
Accuracy	±1 kPa, See note **7** below.
Resolution (Display).....	0.1 kPa
Response	Less than 4 msec. 63% of final value for 30 kPa step change
Over Pressure.....	620 kPa
Burst Pressure	
Tested to 690 kPa without rupture. Do **not** exceed 690 kPa.	
Pressure Drop	
See Chart.	

Volume	
Measurement Range.....	0.001 to 99.99 Liters
Accuracy	
Air and 100% O_2	2% of Reading at flows greater than 2.5 Std L/min
100% N_2	3% of Reading at flows greater than 2.5 Std L/min
100% N_2O ..... *(41403 and 41433 only)*	3% of Reading at flows greater than 2.5 Std L/min See notes **1** through **5** below.
Instrument Temp. Range	
Operation, Ambient	0 to 50°C
Storage, Ambient	-20 to 60°C
Gas Calibrations	
Air, O_2, N_2, N_2O (41403 and 41433 only), User selectable through serial port	
Physical Dimensions	
External Dimensions.....	See Diagram
Tube Adapters	Model 4140/41403: 0.25 inch O.D. straight
(Inlet & Outlet)	Model 4143/41433: 0.375 inch O.D. straight
Weight.....	86 grams
Flow Body Material.....	Polycarbonate
Computer Interface	
Connector.....	8 pin mini-DIN
Type.....	RS232 Serial
Baud Rate.....	38,400
Data Bits	8
Parity	None
Stop Bits.....	1
Flow Control	None
Analog Output (Flow Only)	
Range	0 to 10 V
Resolution.....	13 bit
Maximum Current	5 ma
Flow Accuracy.....	See note **6** below.
Power	
AC adapter or power supplied through mini-DIN 7.5 VDC ± 1.5 V, 300 mA maximum	

Notes:

1 Accuracy stated at standard conditions of 21.1°C and 101.3 kPa.

- Add an additional 0.0003 Std L/min or 0.075% of reading, whichever is greater, per 1°C away from standard conditions when operating within the range of 0°C to 50°C.
- Add an additional 0.015% of reading per 1 kPa above 101.3 kPa or
- Add an additional 0.022% of reading per 1 kPa below 101.3 kPa when operating within the pressure range of 70 kPa to 101.3 kPa.

2 Accuracy stated with gas temperature and flow body temperature within ±10°C of one another.

3 Accuracy stated measuring dry gas (less than 10% R.H.).

4 Includes ±0.5% of reading repeatability.

5 Volumetric flow rate is calculated from the mass flow measurement. Add an additional 0.25% of reading to the flow accuracy to account for the uncertainty in measuring gas temperature and pressure.

6 For analog output, accuracy offset increases from 0.005 to .02 Std L/min.

7 Add uncertainty of 0.2 kPa for every 10°C away from 21.1°C.

**Specifications subject to change without notice.*

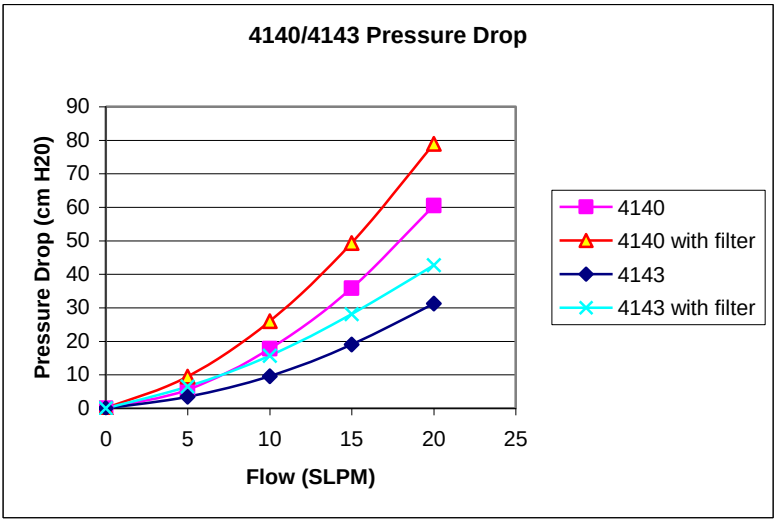

Figure A-1 Pressure Drop

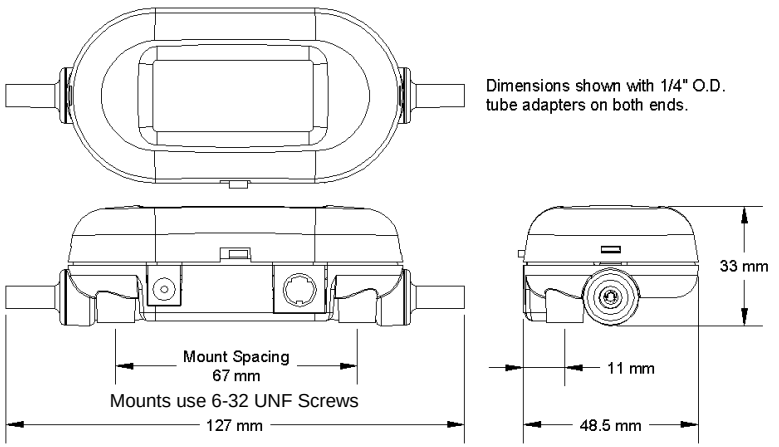

Figure A-2 Model 4140/4143 Dimensions

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Appendix B

Standard Flow Rate vs. Volumetric Flow Rate

Since thermal flow sensors are sensitive to changes in air density and air velocity, all thermal flowmeters indicate flow rates with reference to a set of standard conditions. For TSI instruments, standard conditions are defined as 21.1° C (70° F) and 101.3 kPa (14.7 psia). Other manufacturers may use different values.

Standard flow rate is the flow rate the air would be moving if the temperature and pressure were at standard conditions. It is usually the most useful measure of airflow because it defines the heat-carrying capacity of the air.

Volumetric flow rate is the true volume flow of the gas exiting the flowmeter.

In some instances, volumetric flow rate rather than standard flow rate may be of interest. To display volumetric flow rate, the Model 4140/4143 will multiply the standard flow measurement by the following density correction factor:

$$Volumetric\,Flow = (StandardFlow)\left[\frac{273.15 + T_m}{273.15 + 21.11}\right]\frac{101.3}{P_m}$$

Where

T_m = Gas temperature measured in flow tube in units of degrees Celsius

P_m = Absolute pressure measured in flow tube in units of kPa

To demonstrate the difference in output, consider the following.

Measured flow displays 10 Std L/min at 15C and 117kPa. The volumetric flow as calculated by the Model 4140/4143 would be as follows.

$$Volumetric\,Flow = (10)\left[\frac{273.15 + 15}{273.15 + 21.11}\right]\frac{101.3}{117} = 8.478 L/\min$$

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